

# (12) UK Patent Application (19) GB (11) 2 041 677 A

(21) Application No 8004068  
 (22) Date of filing 7 Feb 1980  
 (30) Priority data  
 (31) 2904904  
 (32) 9 Feb 1979  
 (33) Fed. Rep of Germany (DE)  
 (43) Application published  
 10 Sep 1980  
 (51) INT CL<sup>3</sup>  
 H02P 7/06  
 (52) Domestic classification  
 H2J 2JX 2K 2X CD  
 H2A 1C3M  
 (56) Documents cited  
 None  
 (58) Field of search  
 H2J  
 (71) Applicants  
 Robert Bosch GmbH,  
 Postfach 50,  
 7000 Stuttgart 1,  
 Federal Republic of  
 Germany.  
 (72) Inventors  
 Klaus Bolenz,  
 Peter Bruder,  
 Klaus Metzger,  
 Peter Litterst,  
 Hartmut Nitzsche.  
 (74) Agents  
 W.P. Thompson & Co

(54) Improvements in or relating to  
 direct current motor arrangements

(57) A direct current electric motor  
 arrangement, particularly for driving a  
 blower at a plurality of rotational speed  
 stages, is constructed so as to be  
 switchable to corresponding motor  
 rotational speed stages without neces-  
 sarily requiring power-dissipating  
 series resistors in its electric circuit. The  
 motor armature winding 13 has tv  
 electrically isolated individual windings

(20, 21) Figure 2 (not shown), each of  
 which extends substantially around the  
 entire circumference of the armature  
 and electrical switches 28,29,30 enable  
 the individual armature windings  
 (20,21), which preferably have the same  
 winding data, to be selectively con-  
 nected in series, individually by-passed,  
 or connected in parallel with one  
 another. Switches 28,29,30 are control-  
 led by thermostats 47,48,49 and further  
 speed control may be obtained by  
 adding a series resistor 56.

Fig. 1

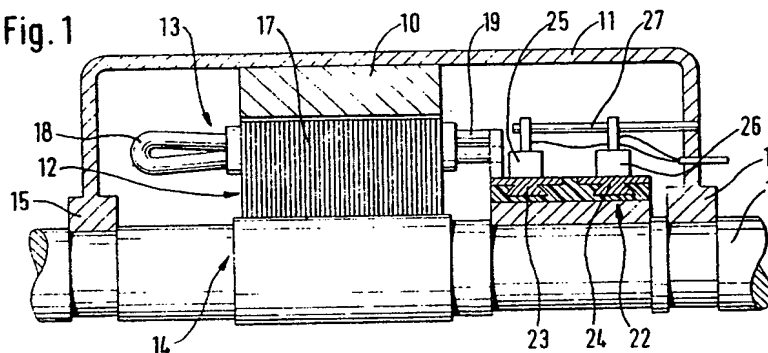
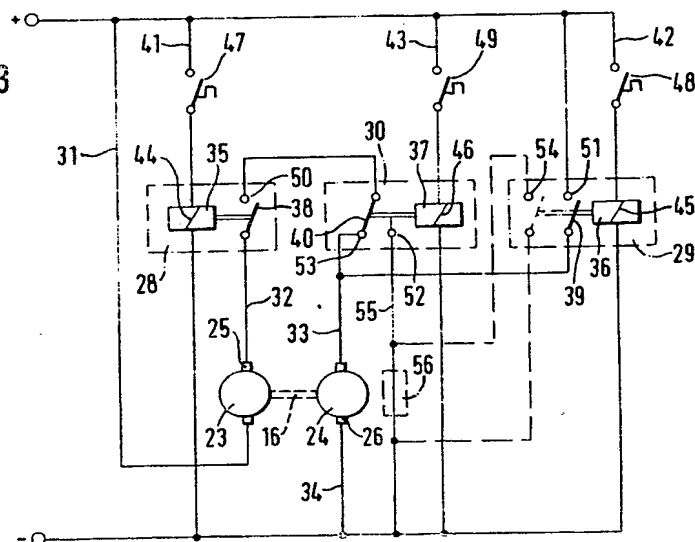


Fig. 3



GB 2 041 677 A

Fig. 1

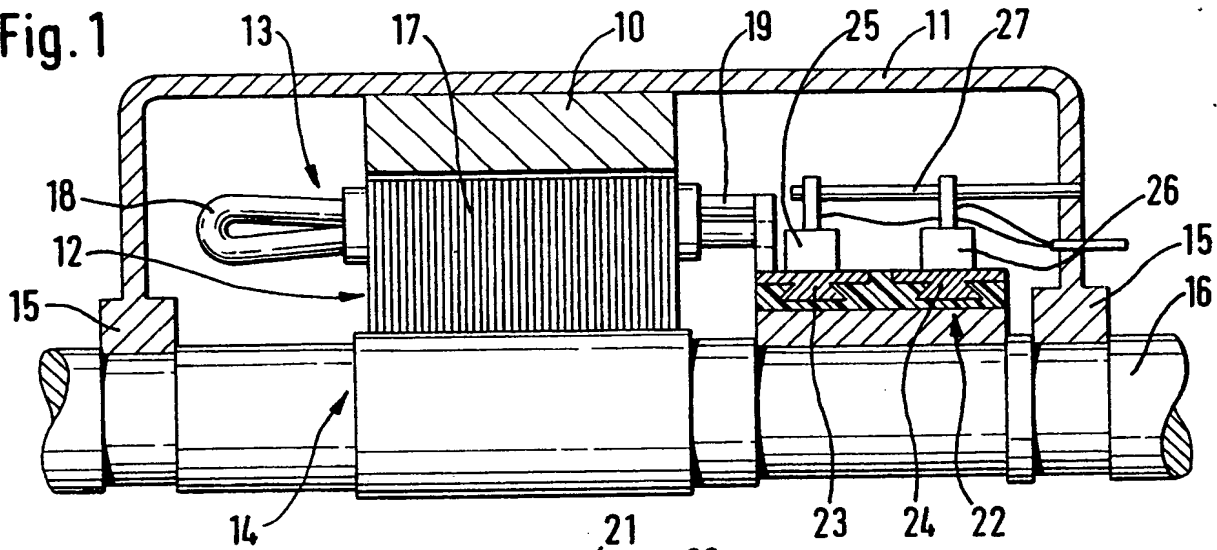


Fig. 2

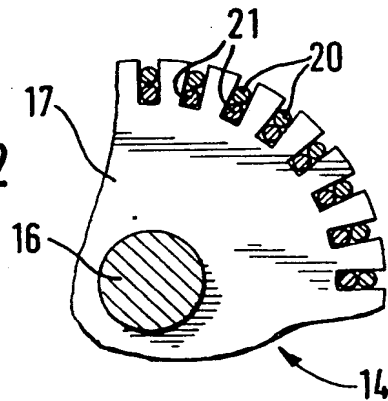
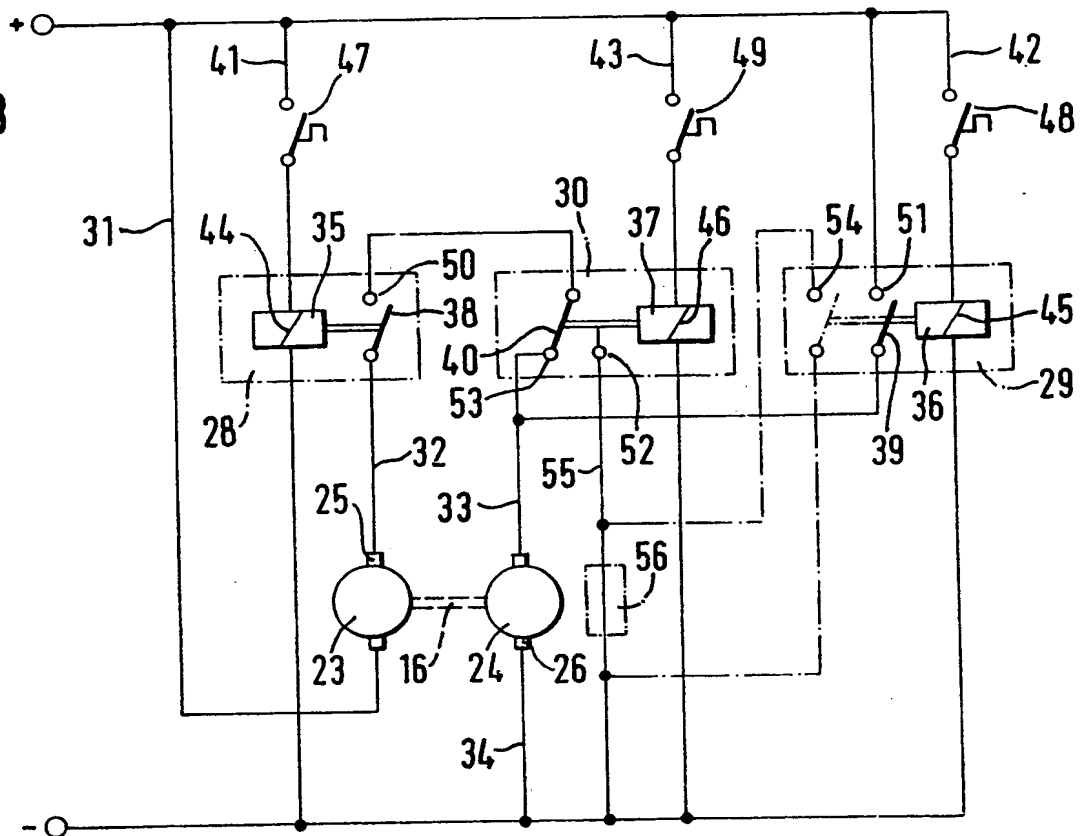


Fig. 3



2/2.

Fig. 4

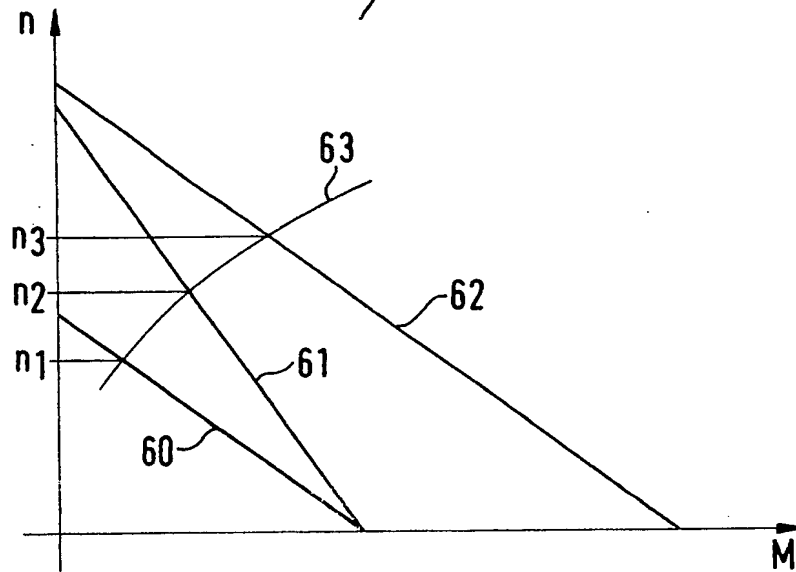
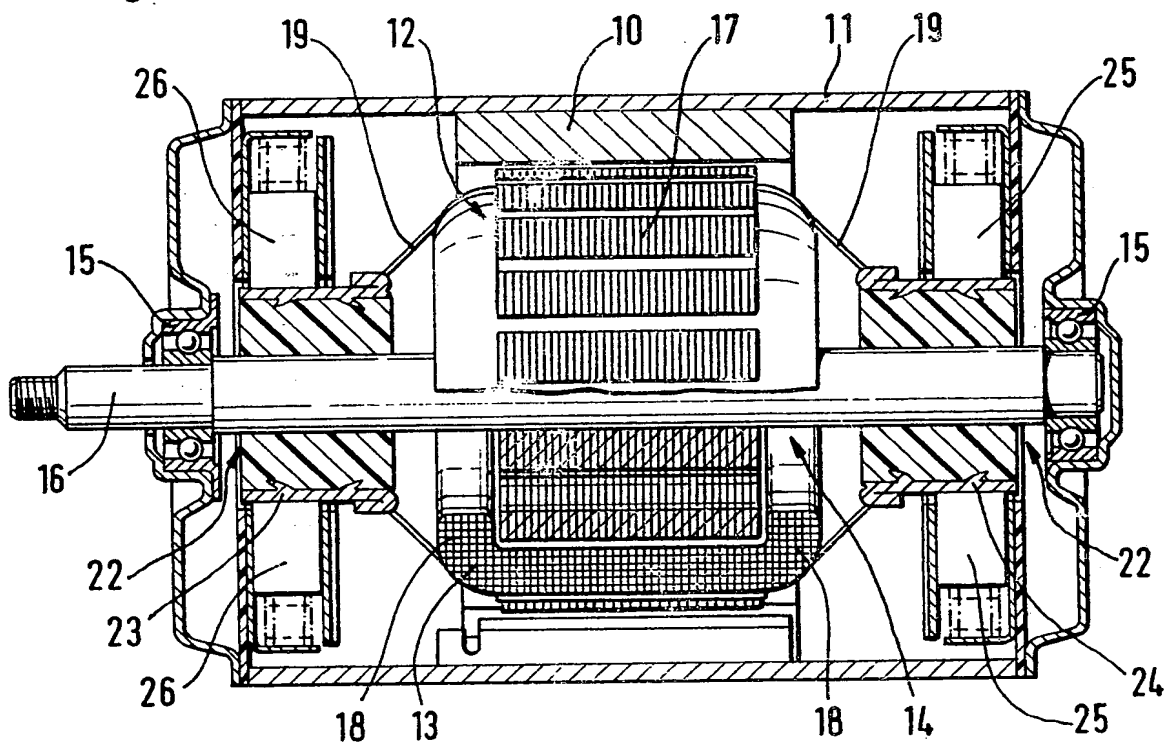


Fig. 5



## SPECIFICATION

### Improvements in or relating to direct current motor arrangements

5 The present invention relates to direct current motor arrangements.

There is a requirement for a fractional horsepower motor especially with a plurality of rotational speed stages and especially for driving a blower.

10 In a known d.c. motor arrangements for a multi-stage cooling blower for an internal combustion engine of a motor vehicle, the rotational speed stages are set by means of series resistors which are switchable into the electrical circuit of the d.c. motor. The rotational speed of the d.c. motor is increased or decreased according to the value of the total effective resistance in the electrical circuit of the d.c. motor. The greater the value of the series resistance, the greater is the drop in the rotational speed.

It is disadvantageous that unused power is consumed in the series resistors, particularly in the lower rotational speed stages of the blower, and the values of the series resistors for high-performance motors have to be correspondingly high.

According to the present invention a direct current motor arrangement comprises an electrical motor having a magnetic pole field structure and an armature having an armature winding comprising at least two electrically isolated individual windings which in each case extend substantially around the entire circumference of the armature, and electrical switches by means of which the individual armature windings can be selectively connected in series with one another, individually by-passed, or connected in parallel with one another.

Preferably the armature winding comprises only two individual windings and the switches are interconnected and connected to the individual armature windings such that the individual armature windings are connected in series in a first switching state, one of the individual armature windings is by-passed in a second switching state, and both the individual armature windings are connected in parallel with one another in a further switching state.

A direct current motor arrangement embodying the present invention can have the advantage that power-dissipating series resistors of this kind can be omitted. The motor can run with substantially the same satisfactory efficiency in all power stages. Additional installation space can be saved by omitting the series resistors.

The invention will be further described by way of example with reference to the accompanying drawings, in which:-

*Figure 1* is a fragmentary longitudinal section through a d.c. motor;

*Figure 2* is a fragmentary cross section through a rotor of the d.c. motor of *Figure 1*;

60 *Figure 3* is a circuit diagram of a d.c. motor arrangement including the motor of *Figure 1*;

*Figure 4* is a graph showing the torque/speed characteristic of the d.c. motor in the circuit diagram of *Figure 3*; and

65 *Figure 5* is a longitudinal section through a d.c.

motor in accordance with a further embodiment of the invention.

The d.c. motor described here is a fractional-horsepower motor which can serve to drive a blower, particularly a cooling blower, switchable to a plurality of rotational speed stages, for an internal combustion engine of a motor vehicle. The d.c. motor is of conventional circularly symmetrical construction, so that only one half of a longitudinal section is shown in *Figure 1*.

75 The d.c. motor has two diametrically oppositely located permanent magnet poles 10 accommodated by a stator 11 which at the same time forms the magnetic flux return yoke for the magnetic circuit.

80 The d.c. motor, illustrated and described in the present instance, is an external pole motor, so that its armature 12 and the armature winding 13 form the rotor 14. The rotor 14 has a shaft 16 which is journaled in bearings 15 on the stator 11, an armature core assembly 17 being mounted on the shaft 16 so as to be non-rotatable relative thereto. The armature core assembly 17 carries the armature winding 13, the coil ends 18 being shown on the left of *Figure 1*, and the ends 19 of the winding being shown on the right of *Figure 1*.

The armature winding 13 comprises two electrically isolated individual windings 20, 21 (*Figure 2*), each of which extends substantially and preferably uniformly around the entire periphery of the armature 12, that is around the periphery of the armature core assembly 17. Preferably, the two individual windings 20 and 21 are identical, that is to say, they have the same winding data. Thus, the armature winding 13 can be double wound.

100 A commutator 22 is mounted on the shaft 16 and is rigidly connected thereto and has for each of the individual windings 20, 21 an independent commutator ring 23, 24 with an associated pair 25, 26 of commutator brushes. The two pairs 25, 26 of brushes (only one brush of each pair is shown in *Figure 1*) are held on a common brush holder 27 on the stator 11. The two commutator rings 23, 24 comprise, like each commutator, individual commutator segments and are electrically isolated from one another. The ends 19 of one individual winding 20 are in each case electrically connected in a known manner to the collector segments of the commutator ring 23, and the ends 19 of the individual winding 21 are electrically connected in a known manner to the collector segments of the commutator ring 24.

115 The d.c. motor also includes electrical switches 28, 29, 30 by means of which the individual windings 20, 21 can be selectively connected in series, individually by-passed, or connected in parallel with one another (*Figure 3*). This is effected by arranging the switches 28 to 30 in the power supply leads 31, 32, 33, 34 of the pairs 25, 26 of commutator brushes.

The shaft 16 of the d.c. motor and the two commutator rings 23, 24 mounted thereon, together with the associated pairs 25, 26 of brushes, are illustrated diagrammatically in *Figure 3*. The switches 28 to 30 are interconnected and are connected to the individual windings 20, 21 by way of the pairs 25, 26 of commutator brushes, such that the individual windings 20, 21 are connected in series in a first

switching state, the individual winding 21 is bypassed or bridged in a second switching state, and the individual windings 20, 21 are connected in parallel with one another in a third switching state.

5 In the present instance, the switches 28 to 30 are in the form of switching relays 35, 36 and 37 having associated moving contacts 38, 39 and 40. It will be appreciated that it is also possible to combine the switches to form a single, manually operable rotary switch whose rotating switching contact switches the three switching states in the manner described. However, the d.c. motor can be automatically switched by means of the switching relays 35 to 37 in response to predeterminable parameters. When, as  
10 in the present instance, the blower driven by the d.c. motor is a cooling blower for an internal combustion engine of a motor vehicle, the d.c. motor can be switched to the various rotational speed changes in dependence upon the temperature of the coolant, such as the temperature of the cooling water. For this purpose, switching elements 47, 48, 49 actuated in dependence upon temperature, such as thermostats, are connected in power supply leads 41, 42 and 43 for the relay windings 44, 45, 46. These  
20 temperature-dependent switching elements 47 to 49 are subjected to the temperature of the coolant.

Each of the first and second switching relays 35, 36 has a normally-open contact 50 and 51 respectively. The third switching relay 37 has both a normally-open contact 52 and a normally-closed contact 53. The series combination comprising the normally-open contact 50 and the normally-closed contact 53 interconnects the two power supply leads 32 and 33 for the pairs 25, 26 of brushes, while the other power supply leads 31 and 34 for the pairs 25, 26 of brushes are connected to the positive pole and the negative pole respectively of a source of direct current. The normally-open contact 51 of the second switching relay 36 is connected between the positive pole of  
40 the source of direct voltage and the power supply lead 33. The normally-open contact 52 of the third switching relay 37 connects the normally-open contact 50 of the first switching relay 35 to the negative pole of the source of direct current. By virtue of the above-described circuit, the normally-open contact 50 of the first switching relay 35 and normally-closed contact 53 of the third switching relay 37 are connected in series with one another and in series with the two individual windings 20, 21. Furthermore, the normally-open contact 52 of the third switching relay 37 is arranged such that it by-passes or bridges the series combination comprising the normally-closed contact 53 of the third switching relay 37 and the individual winding 21 (located  
55 between the first pair 26 of brushes). On the other hand, the normally-open contact 51 and the moving contact 39 of the second switching relay 36 are connected in series with the individual winding 21.

The mode of operation of the d.c. motor described above will be further described hereinafter with reference to a rotational torque/speed graph shown in Figure 4.

As soon as the switch 28 closes, that is to say, the relay 35 applies the moving contact 38 to the  
65 normally-open contact 50 as a result of energisation

of the relay winding 44 of the relay 35, the two individual windings 20, 21 are connected in series with one another by way of two pairs 25, 26 of brushes, the closed normally-open contact 50 and  
70 the closed normally-closed contact 53 of the third switching relay 37. The d.c. motor, which acts electrically like, for example, two motors acting upon a common shaft 16, has a torque/speed characteristic designated 60 in Figure 4. The load characteristic of the driven blower is designated 63 in Figure 4. The d.c. motor runs at the speed  $n_1$  in its first speed state. If the third switch 30, that is to say, the third switching relay 37, is then actuated, the normally-closed contact 53 is opened and the normally-open contact 52 is closed. Thus, the individual winding 21  
75 between the pairs 26 of brushes is currentless since it is by-passed, and only the individual winding 20 is connected to full operating voltage. The torque/speed characteristic of the d.c. motor in this switching state is designated 61 in Figure 4. In this second switching state, the d.c. motor runs at the speed  $n_2$ . As soon as the second switch 29, that is to say, the switching relay 36, is actuated, the normally-open contact 51 is closed. Thus, in addition to the  
85 above-described state of the d.c. motor, the individual winding 21 is connected to the source of direct current by way of pairs 26 of brushes and the closed normally-open contact 51, so that the two individual windings 20 and 21 are then connected in parallel with one another. A torque/speed characteristic designated 62 in Figure 4 is imparted to the d.c. motor and the latter runs at the maximum rotational speed  $n_3$  in the third rotational speed stage. When, as described above, the relay windings 44, 45 and 46  
95 of the switching relays 35, 36, 37 are applied to the source of direct current by way of the temperature-dependent switching elements 47, 48, 49 in dependence upon the temperature of the coolant of the internal combustion engine of the motor vehicle, the d.c. motor is automatically switched to the three  
105 above-described rotational speed stages having the speeds  $n_1$ ,  $n_2$  and  $n_3$  at the instant at which the temperature of the coolant assumes a predetermined value. By way of example, the motor runs at its lowest speed  $n_1$  up to a coolant temperature of 90°C. As soon as a temperature of 95°C has been attained, the temperature-dependent switching element 49 switches on the third switching relay 37. The motor assumes the speed  $n_2$ . When the temperature of the coolant exceeds 100°C, the temperature-dependent switching element 48 responds and connects the second switching relay 36 to the source of direct current. The d.c. motor is switched over to its third rotational speed stage having the rotational  
120 speed  $n_3$ .

A variant of the circuit is shown by dash-dot lines in the circuit diagram of Figure 3. In order to vary the rotational speed of the middle speed stage, or to be able to adjust it within wider limits (in order, for example, to adapt it better to the torque/speed characteristic of the blower), a series resistor 56 is arranged in the by-pass circuit 55 for the individual winding 21. In the second switching state, in which the relay winding 46 of the third relay 37 is energized  
130 and thus the normally-open contact 52 of the third

switching relay 37 is closed, the series resistor 56 is connected in series with the individual winding 20. The torque/speed characteristic, designated 61 in Figure 4, of the motor thereby becomes somewhat steeper in the second switching state, that is to say, the angle of slope between the ordinate and the torque/speed characteristic 61 becomes smaller.

This angle of slope can be varied by corresponding dimensioning of the value of the series resistor 56.

To prevent variation of the torque/speed characteristic 62 of the motor in the third switching state, the series resistor 56 is short-circuited in the present instance. For this purpose, the second switching relay 36 is provided with a further normally-open contact 54. This normally-open contact 54 closes and opens in synchronism with normally-open contact 51. The normally-open contact 54 is connected in parallel with the series resistor 56, so that the series resistor 56 is short-circuited upon closing of the normally-open contact 54. Thus, the series resistor 56 is ineffective in the third switching state.

Figure 5 is an axial section through a d.c. motor in accordance with a further embodiment. The construction and the mode of operation of the motor of Figure 5 are substantially the same as those described above. The same components are therefore provided with the same reference numerals. The only difference between the present d.c. motor and the motor of Figures 1 and 2 resides in the fact that the two independent commutator rings 23 and 24 are not disposed at the same side of the rotor 14 as is shown in Figure 1, but are disposed one at each side of the rotor 14 on the output shaft 16. The two commutator rings 23 and 24 with their associated, respective pairs 25 and 26 of brushes each form, so to speak, an independent commutator. Here also, each commutator ring 23 and 24 is electrically conductively connected to a respective one of the individual windings 20 and 21. Compared with the d.c. motor illustrated in Figure 1, the present d.c. motor has the advantage that its design is more favourable with respect to manufacturing technology and thus it is less expensive to manufacture.

The invention is not limited to the embodiments described above. In particular, the electrical circuit of the two individual windings 20, 21 and of various switches 28, 29, 30 can be such that any optional combination of the individual windings is possible. Thus, for example, the two individual windings 21, 22 can also be connected in parallel in the second, middle switching state and additionally in series with a series resistor which additionally renders it possible to set the middle rotational speed. Advantageously, a d.c. motor in accordance with the invention can be additionally combined with the known type of rotational speed regulation by means of series resistors in the armature circuit. This results in further graduations in the rotational speed with a substantially smaller loss of power than in the conventional regulation.

## CLAIMS

1. A direct current motor arrangement, comprising an electrical motor having a magnetic pole held

structure and an armature having an armature winding comprising at least two electrically isolated individual windings which in each case extend substantially around the entire circumference of the armature and electrical switches by means of which the individual armature windings can be selectively connected in series with one another, individually by-passed, or connected in parallel with one another.

2. A motor arrangement as claimed in claim 1, in which the individual armature windings have the same winding data.

3. A motor arrangement as claimed in claim 1 or 2, in which the field structure has permanently magnetized poles.

4. A motor arrangement as claimed in claim 2 or 3, in which the armature winding is double wound.

5. A motor arrangement as claimed in claim 1 or 2, in which the field structure comprises a stator which carries the magnetic poles, and in which a rotor carries the armature windings and a commutator assembly which has an independent commutator ring and an associated pair of brushes for each of the individual armature windings.

6. A motor arrangement as claimed in claim 5, in which the switches are disposed in power supply leads of the commutator brushes.

7. A motor arrangement as claimed in any of claims 1 to 6, in which the armature winding comprises only two individual windings and the switches are interconnected and connected to the individual armature windings such that the individual armature windings are connected in series in a first switching state, one of the individual armature windings is by-passed in a second switching state, and both the individual armature windings are connected in parallel with one another in a further switching state.

8. A motor arrangement as claimed in any of claims 1 to 7, in which each of the switches comprises a switching relay having associated switching contacts.

9. A motor arrangement as claimed in claim 8, associated with a cooling blower of an internal combustion engine, particularly for motor vehicles, which has a coolant circuit, such as a cooling water circuit, in which the power supply leads of the relay windings incorporate temperature-dependent operated switching elements such as thermostats, which are exposed to the temperature of the coolant.

10. A motor arrangement as claimed in claim 7, and in claim 8 or 9, in which each first and a second switching relay has a normally-open contact, and a third switching relay has a normally-open contact and a normally-closed contact the normally-open contact of the first switching relay and the normally-closed contact of the third switching relay are connected in series with one another and in series with the individual armature windings, the normally-open contact of the third switching relay is arranged to by-pass the series combination comprising the normally-closed contact of the third switching relay and an individual armature winding and that the normally-open contact of the second switching relay is connected in series with the latter individual

armature winding.

11. A motor arrangement as claimed in claims 9 and 10, in which the temperature-dependent operated switching elements are associated with the three switching relays such that, as the temperature of the coolant increases, the first, third and second switching relays are successively energized in this sequence at predetermined temperature stages.

12. A motor arrangement as claimed in any of claims 7 to 11, in which a series resistor is arranged in the branch circuit for by-passing one of the individual armature windings and is short-circuited in the third switching state.

13. A motor arrangement as claimed in claims 10 and 11, in which the series resistor is connected in series with the normally-open contact of the third switching relay, series circuit comprising the normally-open contact of the third switching relay and the series resistor is substituted for the series combination comprising the normally-closed contact of the third switching relay and an individual armature winding when the third switching relay is operated and the second switching relay has a further normally-open contact which is connected in parallel with the series resistor.

14. A motor arrangement as claimed in any of the claims 5 to 12, in which the two independent commutator rings are separated from one another and are arranged one at each side of the rotor.

15. A direct current motor arrangement, constructed and arranged and adapted to operate substantially as hereinbefore particularly described with reference to and as illustrated in the accompanying drawings.